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Successful treatment of ventilator dependent emphysema with Chartis treatment planning and endobronchial valves

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ABSTRACT

INTRODUCTION: Emphysema is a leading cause of disability and death. Patients who require ventilator support as a result of respiratory failure have limited treatment options. We report a successful outcome for a ventilator dependent patient in whom endobronchial valves were inserted into lobes assessed as being without collateral ventilation.

PRESENTATION OF CASE: A 54 year old male patient had been ventilator dependent for two months due to respiratory insufficiency from emphysema. Prior to admission, FEV_1 was 0.89L (25% predicted) and RV was 4.5L (205% predicted). CT scan showed destruction of right lower and middle lobes and left lower lobe. Chartis assessment showed the absence of collateral ventilation. Zephyr endobronchial valves were placed in left and right lower lobes. Lung volume reduction bilaterally was confirmed on chest X-ray and CT scan the following day. On day three, ventilator support was discontinued and there was no requirement for supplementary oxygen. At 30 days post procedure, the RV reduced to 3.2L (142% predicted) and the FEV_1 increased to 1.32L (38% predicted).

DISCUSSION: Hyperinflation in emphysema compromises lung function. For this ventilator dependent patient, there were no other treatment options. Endoscopic lung volume reduction was successfully achieved by bilateral lower lobe placement of Zephyr endobronchial valves with a prior assessment using Chartis to determine the absence of collateral flow in the targeted lobes. The patient achieved an impressive 48% improvement in FEV_1 and a 29% reduction in RV.

CONCLUSION: Endoscopic lung volume reduction assisted by Chartis to plan treatment resulted in a clinical and a health-economic benefit.

1. Introduction

Emphysema is a leading cause of disability and death. Patients who require ventilator support as a result of respiratory failure have limited treatment options. We report a successful outcome for a ventilator dependant patient in whom endobronchial valves were inserted into lobes assessed as being without collateral ventilation.

2. Presentation of case

A 54 year old male patient had been in the Intensive Care Unit on a ventilator for a period of two months as a result of respiratory insufficiency due to emphysema. Due to the prolonged ventilation, he had a tracheostomy. He was transferred to our unit for the bronchoscopic insertion of endobronchial valves with the aim of reducing hyperinflation and improving respiratory function.

He had a 20 year history of Chronic Obstructive Pulmonary Disease. Seven years prior to admission he had ceased smoking and 2 years later had been medically retired from his occupation as a driver.

Three months prior to his admission to the Intensive Care Unit he was oxygen dependent and had an FEV_1 of 0.89L (25% predicted), RV of 4.5L (205% predicted). A CT scan whilst on the ICU showed significant destruction of the right lower and middle lobes and left lower lobe (Fig. 1). Screening for alpha-1-antitrypsin deficiency was negative.

Based upon the CT scan which showed extensive disease in the lower lobes bilaterally, both lower lobes were determined to be target lobes for endo-bronchial valves (EBV). In order to assess the degree of collateral ventilation, under low pressure ventilation, a Chartis® balloon catheter was inserted through the tracheostomy and inserted into the left upper lobe. The lobe was then obstructed by inflating the balloon of the catheter in order to measure air flow and pressure and hence resistance of collateral channels. The same procedure was repeated in the right upper lobe. The assessment demonstrated that the upper lobes had integrity and no collateral flow was present with adjacent lobes (Fig. 2). A decision was made to proceed with the insertion of endobronchial valves in the left lower lobe. Two Zephyr® EBVs were placed in the left lower lobe: one in the common lower lobe bronchus and the other in B6. The

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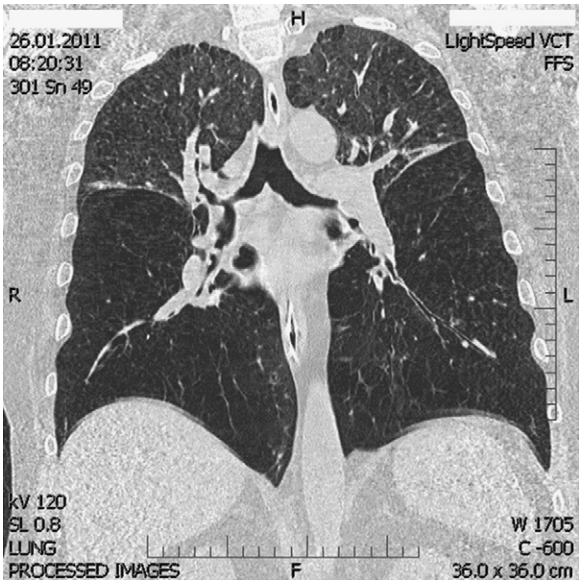


Fig. 1. Pre-procedure CT.

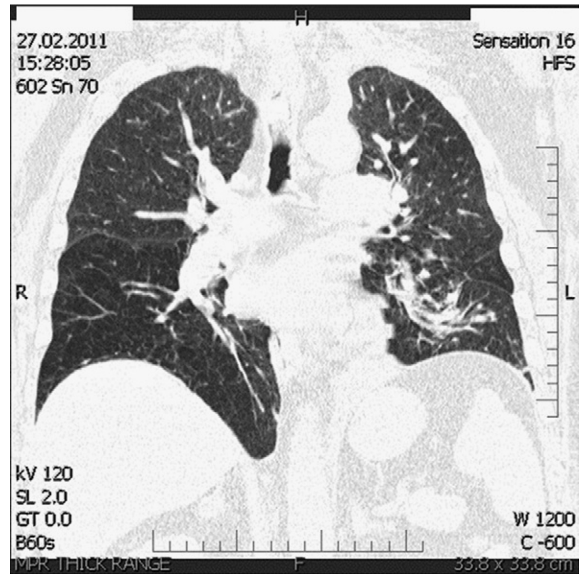


Fig. 4. CT day 2 post procedure.

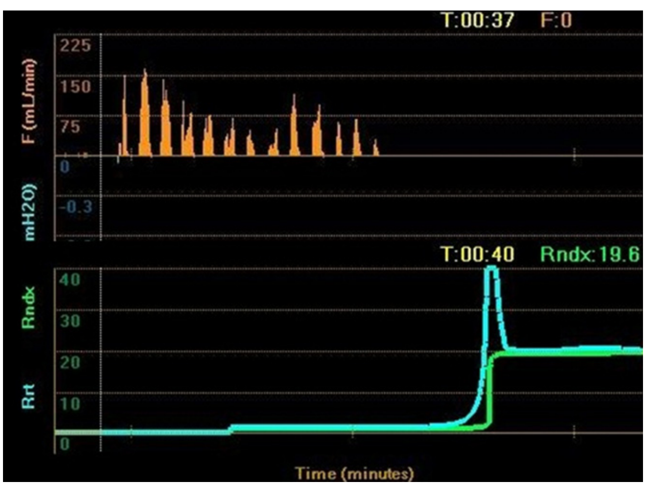


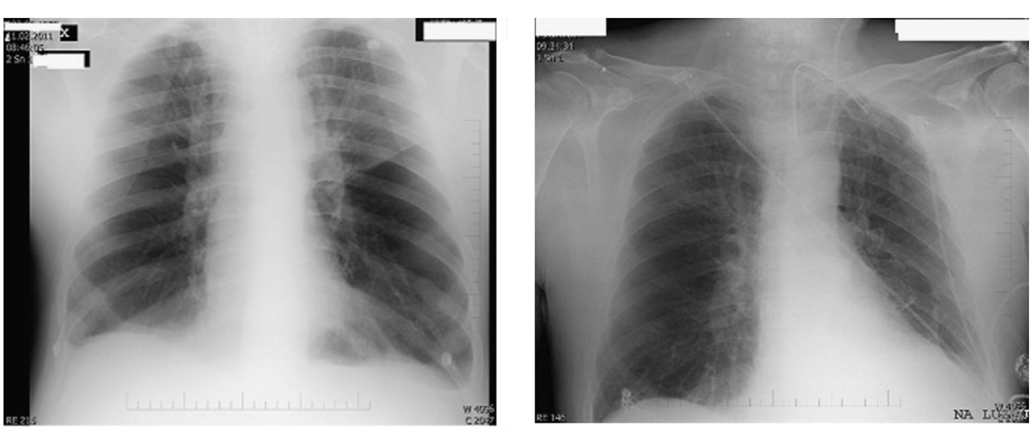
Fig. 2. Chartis flow and index curve.

patient remained stable throughout this procedure. A similar procedure was then performed on the right side, again in the common lower lobe bronchus and B6.

A chest X-ray the following day showed significant lung volume reduction bilaterally with lessening of diaphragmatic flattening and no evidence of pneumothorax (Fig. 3). A CT scan on day 2 confirmed bilateral lung volume reduction and expansion of the healthier upper lobes (Fig. 4). On the third post-operative day, the patient was taken off the ventilator and did not require oxygen support. He was discharged home on day 10 when he was able to begin walking slowly without the need for oxygen. Thirty days later, he showed further improvement in his exercise tolerance and was using oxygen only when undertaking exercise on an exercise bicycle. He had not suffered any complications. His FEV_1 had increased to 1.32L (38% predicted) and RV reduced to 3.2L (142% predicted) (Table 1).

3. Discussion

Emphysema produces alveolar damage resulting in a reduced surface area for gas exchange and loss of elastic recoil. Gas trapping and hyperinflation of the disease lobe causes compression of the adjacent lobe. The main risk factor for emphysema is tobacco



Pre-procedure **Day 1 Post-procedure**

Fig. 3. CXR pre procedure and day 1 post procedure.

Table 1
Pulmonary function before and after Zephyr EBV placement.

Measurement	Baseline litres (% predicted)	30 days post procedure litres (% predicted)
FEV_1	0.89 (25)	1.32 (38)
RV	4.5 (205)	3.2 (142)

smoking and typically this affects the upper lobes to a greater extent than the lower.[1,2] Alpha-1-antitrypsin deficiency is a rarer cause of emphysema and by contrast typically affects the lower lobes. This patient was somewhat unusual in that he had predominantly lower lobe disease although screening for alpha-1-antitrypsin deficiency was negative.

The Zephyr endobronchial valve (Zephyr EBV®) is designed to create volume reduction of the diseased hyperinflated lobe. The device consists of a one-way, silicone, duckbill valve attached to a nickel–titanium (Nitinol), self-expanding retainer that is covered with a silicone membrane. It is implanted in the target bronchus using a flexible delivery catheter that is guided to the targeted bronchus by inserting it through a 2.8 mm working channel of a bronchoscope. It allows air and secretions to escape from the occluded lobe on expiration but prevents air from entering on inspiration.[3] This results in atelectasis of the target lobe, thereby allowing re-expansion of the adjacent, less diseased lobe. In a large randomized controlled study, statistically significant benefit was seen in the treatment group compared to the control group of best medical care. A subgroup of patients obtained a much greater response and suggested that targeting lobes to select those with least collateral ventilation would further improve clinical response.[4]

The Chartis® Pulmonary Assessment System is a catheter-based system that measures pressures and flows during respiration and calculates the resistance of the collateral channels.[5] This enables treatment to be planned such that lung areas with the lowest collateral flow can be targeted, optimizing the clinical effects gained from endobronchial valve therapy.[6]

This ventilator dependent patient had exhausted all medical treatment options. Surgical options for emphysema include lung volume reduction surgery (LVRS) or lung transplant in selected cases. Surgical lung volume reduction therapy has been shown to provide clinical benefit and also a marginal increase in the survival in a subgroup of patients.[7] However, it is associated with significant morbidity and mortality and it has not been widely used in patients who are ventilator dependent. Lung transplant is another surgical option but poor outcomes have been reported in patients requiring pre-operative mechanical ventilation.[8,9]

In this case, by using Chartis® to plan the insertion of EBV, in a patient with no other treatment options, significant lung volume reduction was achieved with a reduction in RV of 29% and an impressive improvement in FEV1 of 48%. In order to give maximum opportunity for an effective response in a severely compromised patient, EBVs were placed bilaterally. Both the Chartis® assessment and the EBV insertion were able to be performed bronchoscopically through the tracheostomy. After two months in an Intensive Care Unit, the patient was able to be ventilator independent, leave hospital and was no longer dependent upon regular supplementary oxygen. He was able to resume an independent life and exercise.

4. Conclusion

In this case, the use of Chartis® to plan EBV treatment resulted not only in clinical benefit but also in a health-economic benefit where a patient was able to transition from ICU ventilator dependency to an independent existence.

Conflict of interest statement

F.J.F. Herth is a member of an Advisory Board for PULMONX. J. Collins is Vice President of Clinical Research and Medical Director of Pulmonx International Sàrl and has a financial interest in the company.

Funding

None.

Ethical approval

Written informed consent was obtained from the patient for publication of this case report and accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal on request.

Author contributions

J. Votruba—data collection, writing and editing.
J. Collins—writing.
F.J.F. Herth—writing and editing.

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